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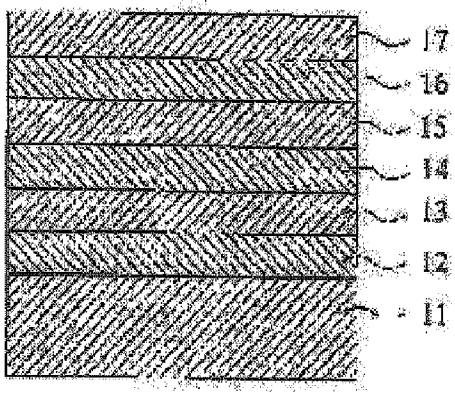
(71)Applicant : HITACHI LTD
(72)Inventor : TANAHASHI KIWAMU
KANBE TETSUYA
MATSUNUMA SATORU
ISHIKAWA AKIRA

(54) MAGNETIC RECORDING MEDIUM AND MAGNETIC MEMORY DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a magnetic memory device having ≥10 Gbit/inch2 recording density, low error rate and excellent reliability.
SOLUTION: The magnetic recording medium has a seed layer on a substrate and has a magnetic layer formed on the seed layer with a base layer interposed. The seed layer of the magnetic recording medium is formed from an amorphous alloy or fine crystal alloy containing Ni, Ta and Zr, and the base layer is formed from an alloy essentially consisting of Cr and containing Ti. The magnetic layer consists of a first magnetic layer in contact with the base layer and a second magnetic layer formed on the first magnetic layer. The first magnetic layer is substantially formed from a Co-Cr-Pt alloy having a hexagonal close-packed(HCP) structure. The second magnetic layer is substantially formed from a Co-Cr-Pt-B alloy having a hexagonal close-packed(HCP) structure.

図1



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CLAIMS

[Claim(s)]
[Claim 1] The magnetic-recording medium by which sequential formation of the seed layer which has the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr on a substrate, the substrate layer which uses Cr as a principal component, and the magnetic layer was carried out.
[Claim 2] The magnetic-recording medium characterized by carrying out the laminating of a substrate layer with the field (001) of said crystal grain parallel [consisting of crystal grain of body-centered cubic structure substantially] to a substrate, and the magnetic layer which has hexagonal close-packed structure substantially and uses Co alloy as a principal component one by one by using as a principal component the seed layer which has the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr on a substrate, and Cr.
[Claim 3] The magnetic-recording medium according to claim 1 or 2 characterized by preparing the interlayer who has an alloy containing Cr and Mo between said substrate layers and said magnetic layers.
[Claim 4] The seed layer which has the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr on a substrate, Cr and Ti are included. A substrate layer with the field (001) of said crystal grain parallel [consisting of crystal grain of body-centered cubic structure substantially] to a substrate, The magnetic-recording medium containing Co, and Cr and Pt which contains Co, Cr and Pt, and Ta or B substantially and by which the laminating of the second magnetic layer of hexagonal close-packed structure was carried out one by one substantially. [the first magnetic layer of hexagonal close-packed structure,]
[Claim 5] Co, Cr and Pt, and the magnetic-recording medium containing Ta or B by which the laminating of the magnetic layer of hexagonal close-packed structure was carried out one by one substantially. [the interlayer in whom it consists of crystal grain of body-centered cubic structure substantially, and the field (001) of said crystal grain contains a substrate layer parallel to a substrate, and Cr and Mo on a substrate including the seed layer which has the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr and Cr and Ti.]
[Claim 6] Said seed layer containing nickel, and Ta and Zr is a magnetic storage medium given in claims 1-5 characterized by for Ta concentration being less than [more than 30at%60at%], and Zr concentration being more than 5at% and less than [20at%].
[Claim 7] The seed layer which has the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr on a substrate, Cr is used as a principal component. A substrate layer with the field (001) of said crystal grain parallel [consisting of crystal grain of body-centered cubic structure substantially] to a substrate, The magnetic-recording medium by which the laminating of the magnetic layer which uses as a principal component Co alloy which has hexagonal close-packed structure substantially was carried out one by one, Magnetic storage characterized by having the magnetic head which has the mechanical component which carries out the rotation drive of this magnetic-recording medium, and the playback section which consists of the Records Department and the magneto-resistive effect mold magnetic head, and the means to which relative motion of said magnetic head is carried out to said magnetic-recording medium.
[Claim 8] Magnetic storage according to claim 7 characterized by preparing the interlayer who has an alloy containing Cr and Mo between said substrate layers and said magnetic layers.
[Claim 9] Said seed layer is magnetic storage according to claim 7 or 8 characterized by for Ta concentration being less than [more than 30at%60at%], and Zr concentration being more than 5at% and less than [20at%].

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to magnetic storage and a magnetic-recording medium, and relates to the magnetic storage which has the surface recording density of 10 gigabits or more per 1 square inch especially, and the magnetic-recording medium for realizing this.
[0002]
[Description of the Prior Art] In recent years, the increment of the amount of information which a computer treats is being enhanced, and the magnetic disk drive which is external storage is asked for the more and more large-capacity-izing and fast transmission-ization. The magnetic disk drive which now has the recording density of the 4giga bid class per a maximum of 1 square inch has come to be produced commercially. The Records Department and the playback section are divided into the magnetic head of such a high density magnetic disk drive, and the compound-die head which used the electromagnetic-induction mold magnetic head for the Records Department, and used the magneto-resistive effect mold head for the playback section is adopted as it. Also not only from the signal of a medium but from the noise, since sensibility is high, as for the magneto-resistive effect mold head, the magnetic-recording medium is asked for low noise-ization more than before. The medium noise in the recording method within a field mainly originates in turbulence of the magnetization in the magnetization transition region between record bits, and narrowing this field leads to reduction of a medium noise. It is effective in this to make a magnetic particle detailed, and to weaken the interaction between particles, and to make flux reversal size small. Detailed-ization of a magnetic particle uses the epitaxial relation between a magnetic layer and a substrate layer, and can be realized by making a substrate particle detailed. Moreover, in order to be able to weaken the interaction between particles by making a grain boundary segregate nonmagnetic Cr and to promote this segregation of Cr, the CoCrPt alloy of high Cr concentration, the CoCrPtTa alloy which carried out Ta addition, the CoCrPtB alloy which added B are examined.
[0003]
[Problem(s) to be Solved by the Invention] Since it corresponds to the track recording density which increases every year, it is necessary to make high coercive force (Hc) of a magnetic-recording medium. Although it is necessary to raise Pt concentration for obtaining high Hc with the CoCrPt alloy of high Cr concentration, when Pt concentration is raised, there is an inclination for an overwrite property to fall rapidly. On the other hand, even if the CoCrPtTa alloy which carried out Ta addition does not make Cr concentration so high, the grain boundary segregation of Cr happens, and since whenever [magnetic isolated / of a magnetic particle] is high, high Hc is obtained by comparatively low Pt concentration. However, even when a CoCrPtTa alloy is used, in order to raise Cr concentration in order to reduce a medium noise further, and to secure high Hc with a more detailed particle size, it is necessary to raise Pt concentration. However, in the presentation with high Cr concentration and Pt concentration, the problem from which magnetic properties with it and record reproducing characteristics are not acquired arises with a CoCrPtTa alloy. [the difficult consequently epitaxial growth of a substrate layer and a magnetic layer and] [sufficient] Moreover, such a problem is seen even when the CoCrPtB alloy magnetic layer which raised Pt concentration is used. This invention is made in order to solve the above-mentioned technical problem. It aims at offering the magnetic storage which has high S/N with the recording density of 10 gigabits or more per 1 square inch, and was more specifically excellent in dependability.
[0004]
[Means for Solving the Problem] The unit or two or more substrate layers which were formed on the seed layer and this seed layer on the substrate in this invention, The magnetic-recording medium which has the unit or two or more magnetic layers which were formed on this substrate layer, The mechanical component which drives this in the record direction, and the rec/play separate-type magnetic head which combined the electromagnetic-induction mold magnetic head for record, and the magneto-resistive effect mold magnetic head for playback, In the magnetic storage which has the means to which relative motion of said magnetic head is carried out to said magnetic-recording medium, and a record regenerative-signal processing means for performing output signal playback from the signal input of said magnetic head, and this magnetic head The seed layer of said magnetic-recording medium is used as the amorphous alloy or microcrystal alloy containing nickel, and Ta and Zr. And it considers as the alloy which uses Cr as a principal component for said unit or two or more substrate layers, and contains Ti. And said unit or two or more magnetic layers are constituted from

the first magnetic layer which touches said substrate layer, and the second magnetic layer formed on this first magnetic layer. And the above-mentioned purpose is attained by using said first magnetic layer as the Co-Cr-Pt alloy of HCP structure substantially, and using said second magnetic layer as the Co-Cr-Pt-B alloy or Co-Cr-Pt-Ta alloy of HCP structure substantially. The substrate layer of said magnetic-recording medium has the role which carries out orientation of the C shaft of the magnetic layer which used Co alloy of HCP structure substantially into a film surface, and makes a particle make it detailed. Since a problem arises for grid adjustment in Cr substrate layer generally used when using the CoCrPt alloy of high Pt concentration for a magnetic layer, it is effective to use the Cr-Ti alloy of BCC structure substantially as indicated by JP,62-257617,A. Compared with Cr, since the lattice spacing is large, a CrTi alloy has the good CoCrPt alloy and grid adjustment of high Pt concentration, and it can make particle size detailed.

[0005] However, there is a problem to which the orientation which is crystal orientation desirable as a substrate layer (001) becomes weak as Ti concentration is made high. When this invention persons examined various ingredients as a seed layer formed between a substrate and a substrate layer and a NiTaZr alloy was used as a seed layer, they found out that the orientation (001) of a CrTi alloy substrate layer became strong, and substrate particle size could be made small. It is thought that the NiTaZr alloy is an amorphous substance or a microcrystal since a clear diffraction peak is not seen in an X diffraction and a diffraction spot and a diffraction ring with clear electron diffraction are not seen. As a presentation of a NiTaZr alloy, it is desirable to make more than 30at%, less than [60at%], and Zr concentration into more than 5at% and less than [20at%] for Ta concentration. Since there will be said case where crystallization of a NiTaZr alloy takes place according to film production conditions and the stacking tendency (001) of a CrTi alloy substrate layer will deteriorate Ta concentration if it is made out of range, it is not desirable. Moreover, since orientation will deteriorate if substrate particle size will ****** although orientation of the CrTi alloy substrate layer is carried out strongly (001) if Zr concentration is made fewer than 5at(s)%, and it is made larger than 20at% (001), it is not desirable. The magnetic layer of said magnetic-recording medium can be constituted from the first magnetic layer which touches a substrate layer, and the second magnetic layer formed on this first magnetic layer, and a CoCrPtTa alloy or a CoCrPtB alloy can be used for it as an ingredient of said second magnetic layer, using a CoCrPt alloy as an ingredient of said first magnetic layer. Especially a CoCrPtB alloy is desirable, when particle size is small, there is an inclination for high Hc to be obtained and an output resolution is raised. Moreover, the magnetic layer of the so-called granular structure which consists of the high CoPt alloy and high oxide (SiO2, aluminum2O3 grade) of a magnetic anisotropy as said second magnetic layer can also be used. Pt concentration is [an inclination for an overwrite property to deteriorate in a high presentation] and is not desirable if a magnetic layer is used as the monolayer of a CoCrPt alloy. Moreover, when the interlayer who consists of a CrMo alloy is formed between a magnetic layer and a substrate layer, the monolayer of a CoCrPtTa alloy or a CoCrPtB alloy can be used as a magnetic layer. Moreover, it is also possible to use the magnetic layer of the granular structure which consists of a CoPt alloy and an oxide. When especially the monolayer of a CoCrPtB alloy is used, there are a detailed particle size and an inclination acquired by coincidence in high Hc, a low medium noise and a high output resolution can be realized, and it is desirable. Although epitaxial growth becomes difficult in the presentation field where Cr and Pt concentration are high when a direct CoCrPtTa alloy or a CoCrPtB alloy magnetic layer is formed on a CrTi alloy substrate layer, a CrMo alloy interlayer can do orientation of a CoCrPtTa alloy or the C shaft of a CoCrPtB alloy magnetic layer into a film surface by using. Since a CrMo alloy is an alloy of all rate dissolution molds, it can raise grid adjustment with a CoCrPtTa alloy or a CoCrPtB alloy magnetic layer by adjusting the concentration of big Mo of an atomic radius compared with Cr. Moreover, since a CrMo alloy interlayer's particle size tends to increase with thickness, thickness needs to use it in the thin range. As for a CrMo alloy interlayer's thickness, it is desirable to be referred to as 3nm or more and 10nm or less from the point of maintaining a good crystal stacking tendency and suppressing hypertrophy of particle size. It is necessary to use what was excellent in surface smooth nature as a substrate, and the aluminum-Mg substrate with which NiP was specifically formed in the front face, a glass substrate, SiO2 substrate, a SiC substrate, a carbon substrate, etc. can be used. Although texture ring processing is usually performed to the aluminum-Mg substrate on the front face and the magnetic anisotropy is given to the substrate hoop direction, even when mechanical texture ring processing of a glass substrate etc. is a difficult substrate, a magnetic anisotropy can be given to a substrate hoop direction by performing light texture ring processing of an about [Ra=1nm], after forming a seed layer. A reliable magnetic-recording medium is obtained by forming 3nm or more in thickness and the film 12nm or less which use carbon as a principal component as a protective layer of a magnetic layer, and forming lubricating layers, such as a perfluoroalkyl polyether, by the thickness of 1nm or more and 10nm or less further. As for the magnetic-reluctance sensor section of the magnetic-reluctance mold magnetic head for playback used for the magnetic storage of this invention, it is desirable to form between the shielding layers of two sheets which consist of a soft magnetic material with which only the distance of 0.12 micrometers or more and 0.18 micrometers or less was separated mutually. Since the insulation of a shielding layer and the magnetic-reluctance sensor section may be spoiled if it becomes smaller than 0.12 micrometers preferably, since resolution will fall if spacing of a shielding layer becomes larger than 0.18 micrometers, it is not desirable. Furthermore, when the magnetization direction changes said magneto-resistive effect mold head with external magnetic fields relatively mutually, by constituting by the magnetic-reluctance sensor containing two or more conductive magnetic layers which produce a big resistance change, and the conductive non-magnetic layer

arranged between these conductive magnetic layers, a regenerative signal can be raised and magnetic storage which has high dependability with the recording density of 10 gigabits or more per 1 square inch can be realized.

[0006]

[Embodiment of the Invention] Example 1: The lamination of the magnetic-recording medium of this example is shown in drawing 1 . The soda lime glass with which the chemical strengthening of the 2.5inch mold which carried out alkali cleaning was carried out to the substrate 11 In the seed layer 12, the nickel-37.5at%Ta-10at% Zr alloy layer whose thickness is 50nm In the substrate layer 13, the Co-22at%Cr-14at%Pt alloy layer whose thickness is 10nm about the Cr-20at%Ti alloy layer whose thickness is 30nm at the first magnetic layer 14 Thickness carried out sequential formation of the 10nm Co-21at%Cr-12at%Pt-3at%Ta alloy layer by the DC magnetron sputtering method at the protective layer 16 at the second magnetic layer 15 using the carbon layer which is 6nm. In film production conditions, the argon partial pressure of gas heated 5mTorr(s) and substrate temperature to 270 degrees C at the lamp heater after seed layer 12 formation. The lubricating layer 17 diluted and applied the ingredient of a perfluoroalkyl polyether system with the fluorocarbon ingredient. Moreover, the medium using the Co-22at%Cr-14at%Pt alloy layer whose thickness is 18nm at the magnetic layer 21 of a monolayer about the medium using the nickel-37.5at%Ta alloy layer whose thickness is 50nm as shown in drawing 2 as an example 2 of a comparison was produced in the seed layer 12 as an example 1 of a comparison.

[0007] The record reproducing characteristics in track-recording-density 400kFCI are shown with the value of the coercive force measured in the magnetic-head transit direction of the medium of an example 1 and the examples 1 and 2 of a comparison, and a coercive force remanence ratio in Table 1.

[0008]

[Table 1]

表1

	Hc [kOe]	S*	SIf/N [dB]	出力分解能 [%]	重ね書き特性 [dB]
実施例 1	2.95	0.73	31.4	55.0	37.7
比較例 1	3.25	0.76	27.6	54.7	36.1
比較例 2	3.14	0.75	28.3	55.3	29.8
実施例 2	2.92	0.72	32.5	54.8	37.9
比較例 3	0.51	0.02	-	-	-

[0009] The playback component of the spin bulb mold which the distance between shielding layers set to 0.15 micrometers, and the magnetic head which gap length becomes from a 0.23-micrometer electromagnetic-induction mold write-in component were used for record reproducing characteristics. Slf -- the output of an isolated playback wave, and N -- the medium noise in the track recording density of 400kFCI(s) -- it is -- these ratios -- Slf/N estimated medium S/N. The output resolution expressed as the percentage the value which broke the playback output of 200kFCI(s) by the playback output of 25kFCI(s). Moreover, 1f signal after writing in 1f signal (47.5kFCI) first and carrying out overwrite of the 2f signal (400kFCI) as an overwrite property remained unmelted, and reinforcement was evaluated. As for the static magnetism property of the medium of an example 1 and the examples 1 and 2 of a comparison, the value almost equivalent to about 0.75 was acquired [Hc] for about 3 kOe(s) and S*. Although the output resolution was equivalent compared with the medium of the example 1 of a comparison, the record reproducing characteristics of the medium of an example 1 had high Slf/N 3.8dB, and were good. Although the value with a as high output resolution as 55.3% was acquired, compared with the medium of an example 1, Slf/N was low 3.1dB, and, as for the medium of the example 2 of a comparison, the overwrite property was much less than 29.8dB and 36dB needed practically. In order to clarify the factor of the difference of Slf/N of the medium of an example 1 and the example 1 of a comparison, the crystal stacking tendency was investigated with the X-ray diffraction method.

[0010] The X diffraction performed Cu using the X-ray diffractometer (RINT made from physical science) used as a target. K alpha rays were used as a line source. The Measuring condition was made into the applied voltage of 40kV, and 100mA of force current using the theta-2theta method.

[0011] The X diffraction pattern of a medium is shown in drawing 3 . Only the 002 diffraction peak of a substrate layer and the 11.0 diffraction peak of the HCP structure of a magnetic layer are seen, and not both media can check the diffraction peak from a seed layer. the thickness of a seed layer is comparatively as thick as 50nm -- being alike -- since a ******** diffraction peak is not seen, it is thought that the nickel-37.5at% Ta-10at%Zr alloy and the nickel-37.5at%Ta alloy are an amorphous or very detailed crystal. Although the substrate layer formed on the seed layer is carrying out orientation of both the media (001), the 002 diffraction peak intensity of the medium of the example 1 of a comparison is strong 3 or more times compared with it of the medium of an example 1. By the atomic force microscope, when the surface type voice of the substrate layer of both media was observed, as for the medium of the example 1 of a comparison, the irregularity whose period is about 16nm was seen to the irregularity whose period is about 12nm having been seen, as for the medium of an example 1. Since it is thought that this irregularity is mostly equivalent to the magnitude of crystal grain, by the medium of the example 1 of a comparison, it turns out that the particle size of a substrate layer has ******ed . That is, although the orientation where a substrate layer is strong (001)

will be obtained if a NiTa alloy is used for a seed layer, substrate particle size ******s and detailed-ization of a magnetic particle cannot be realized. By using the NiTaZr alloy which added Zr in the seed layer to it, with the orientation (001) of a substrate layer maintained, hypertrophy of substrate particle size can be controlled, consequently a magnetic particle is made detailed. Therefore, as for one high 3.8dB, compared with it of the medium of the example 1 of a comparison, detailed-ization of a magnetic particle size is considered to be the main factor for SIf/N of the medium of an example 1. The mimetic diagram and verticval mimetic diagram of magnetic storage of this example are shown in drawing 4 (a) and drawing 4 (B). This equipment is magnetic storage with the configuration of the common knowledge which comes to have the magnetic-recording medium 41, the mechanical component 42 which carries out the rotation drive of this, the magnetic head 43 and its driving means 44, and the record regenerative-signal processing means 45 of said magnetic head. The mimetic diagram of the structure of the magnetic head used for this magnetic storage is shown in drawing 5 . This magnetic head is a rec/play separate-type head which combined the electromagnetic-induction mold magnetic head for record and the magneto-resistive effect mold head for playback which were formed on the magnetic-head slider base 57. The magnetic head for record is the induction type thin film magnetic head which consists of a coil 53 interlinked to the record magnetic poles 51 and 52 of a pair, and it, and the gap thickness between record magnetic poles could be 0.23 micrometers. Moreover, both the magnetic poles 52 are the magnetic-shielding layer 56 with a thickness of 1 micrometer and a pair, it serves also as magnetic shielding of the magnetic head for playback, and the distance between these shielding layers is 0.15 micrometers. The magnetic head for playback is a magneto-resistive effect mold head which serves as the magneto-resistive effect sensor 54 from the conductor layer 55 used as an electrode. In addition, in drawing 5 , the gap layer and shielding layer between record magnetic poles are omitted. The longitudinal-section structure of a magnetic-reluctance sensor is shown in drawing 6 . The signal detection field 61 of a magnetometric sensor is the structure where sequential formation of the Fe-20at%Mn antiferromagnetism alloy layer 67 of the 66 or 10nm of the second magnetic layer of 65 or 3nm of Cu interlayers of the 64 or 1.5nm of the first magnetic layer of 63 or 7nm of 5nm of Ta buffer layers was carried out on the gap layer 62 of Oxidization aluminum. Co was used for the second magnetic layer 66 at the first magnetic layer 64 using the nickel-20at%Fe alloy. Magnetization of the second magnetic layer 66 is being fixed to the one direction by the exchange field from the antiferromagnetism alloy 67. On the other hand, the direction of magnetization of the second magnetic layer 66 and the first magnetic layer 64 which touches through the nonmagnetic interlayer 65 changes with the leakage fields from a magnetic-recording medium. Change arises in resistance of the whole film of three layers with change of the relative direction of magnetization of such two magnetic layers. This phenomenon is called the spin bulb effectiveness. There is the taper section 68 processed into the taper configuration in the both ends of the signal detection field 61. The taper section 68 consists of electrodes 70 of the pair for taking out the permanent magnet layer 69 and the signal formed on it. A permanent magnet 69 has high coercive force, it is important that the magnetization direction does not change easily, and CoCr, a CoCrPt alloy, etc. are used. When the medium of an example 1 was built into the above-mentioned magnetic storage and the conditions of 15nm of head flying heights, track-recording-density 425kFCI, and track density 25kTPI estimated record reproducing characteristics, in the 10 to 50 degrees C temperature requirement, the record reproducing-characteristics specification with a surface recording density of 10 gigabits [per 1 square inch] was fulfilled enough. And the number of bit errors after 50,000 head seeking trials from inner circumference to a periphery is 10 bits/page or less, and has attained 300,000 hours with Mean Time Between Failure.

[0012] Example 2: The lamination of the magnetic-recording medium used for drawing 7 by this example is shown. A 5nm Cr-40at%Mo alloy is used as an interlayer 71, a 18nm Co-21at%Cr-13at%Pt-4at%B alloy is used as a magnetic layer 72, and another layer and other film production conditions are the same as that of the medium of an example 1. Moreover, the medium which formed the direct magnetic layer 72 on the substrate layer 13 as an example 3 of a comparison as shown in drawing 8 was produced. The record reproducing characteristics in track-recording-density 400kFCI are collectively shown with the value of the coercive force measured in the magnetic-head transit direction of the medium of an example 2 and the example 3 of a comparison, and a coercive force remanence ratio in Table 1. The static magnetism property with the medium of an example 2 equivalent to the medium of an example 1 was acquired, and, as for record reproducing characteristics, the value with as high SIf/N as 32.5dB was acquired. On the other hand, static magnetism property with Hc sufficient [the medium of the example 3 of a comparison / 0.51kOe(s) and S*] to evaluate 0.02 and record reproducing characteristics was not acquired. The X diffraction pattern of the medium of an example 2 and the example 3 of a comparison is shown in drawing 9 . The Measuring condition of an X diffraction is the same as an example 1.

[0013] By the medium of an example 2, with 5nm, since thickness is thin, it cannot check an interlayer's 71 diffraction peak, but since the 11.0 diffraction peak of the HCP structure of a magnetic layer 72 is seen, it is the substrate layer 13 and an interlayer 71 doing orientation (001), and growing epitaxially on it, and it turns out that the magnetic layer is carrying out orientation (11.0). On the other hand, the 00.2 diffraction peak of the HCP structure of a magnetic layer 72 is seen, and, as for the medium of the example 3 of a comparison, serves as orientation where C shaft of a magnetic layer started perpendicularly to the substrate. Thus, the Cr-40at%Mo alloy used as an interlayer 71 of the medium of an example 2 carries out orientation of the C shaft of a magnetic layer 72 into a film surface, and has the role which raises a static magnetism property. When the medium of an example 2 was built into the magnetic storage of an example 1 and the conditions of

15nm of head flying heights, track-recording-density 425kFCI, and track density 25kTPI estimated record reproducing characteristics, in the 10 to 50 degrees C temperature requirement, the record reproducing-characteristics specification with a surface recording density of 10 gigabits [per 1 square inch] was fulfilled enough. And the number of bit errors after 50,000 head seeking trials from inner circumference to a periphery is 10 bits/page or less, and has attained 300,000 hours with Mean Time Between Failure.

[0014] Example 3: The medium of an example 2 and the medium using the aluminum-Mg alloy substrate with which NiP plating of a 2.5inch mold was performed to the substrate 11 by the same lamination were produced. In addition, texture ring processing of Ra=3nm was performed to the substrate 11. Film production conditions and a lubricating layer 17 are the same as that of the medium of an example 1. Moreover, the medium which formed the substrate layer 13 directly on the substrate 11 as an example 4 of a comparison as shown in drawing 10 was produced. The record reproducing characteristics in track-recording-density 400kFCI are collectively shown with the value of the coercive force measured towards intersecting perpendicularly with the magnetic-head transit direction of the medium of an example 3 and the example 4 of a comparison, and it, and a coercive force remanence ratio in Table 2.

[0015]

[Table 2]

表2

	Hc [kOe]	S*	SIf/N [dB]	出力分解能 [%]	重ね書き特性 [dB]
実施例 3	3.24 (2.85)	0.78 (0.60)	29.2	56.6	37.5
比較例 4	3.03(2.90)	0.79 (0.66)	29.3	52.9	37.3
実施例 4	3.12 (2.74)	0.76 (0.61)	31.9	55.9	37.2

*括弧内に示す値は、磁気ヘッド走行方向と直交する方向で測定した値

[0016] The value shown in the parenthesis of Hc and S* here is a value measured towards intersecting perpendicularly with the magnetic-head transit direction. a magnetic anisotropy gives the medium of an example 3 in the magnetic-head transit direction -- having -- Hc and S* -- the medium of the example 4 of a comparison -- comparing -- Hc -- 0.23kOe(s) and S*0.08 -- the high value was acquired. This is forming the seed layer 12, the stacking tendency (001) of the substrate layer 13 and the orientation (11.0) of a magnetic layer become strong, and since the effectiveness of the magnetic-anisotropy grant by texture ring processing was heightened, it is considered. Thereby, as for the output resolution, the value high 3.7% was acquired compared with the medium of the example 4 of a comparison. When the medium of an example 3 was built into the magnetic storage of an example 1 and the conditions of 15nm of head flying heights, track-recording-density 425kFCI, and track density 25kTPI estimated record reproducing characteristics, in the 10 to 50 degrees C temperature requirement, the record reproducing-characteristics specification with a surface recording density of 10 gigabits [per 1 square inch] was fulfilled enough. And the number of bit errors after 50,000 head seeking trials from inner circumference to a periphery is 10 bits/page or less, and has attained 300,000 hours with Mean Time Between Failure.

[0017] Example 4: By the same lamination as an example 2, it took out from film production equipment after forming the seed layer 12, texture ring processing of Ra=1nm was performed, and sequential formation of the substrate layer 13, the first magnetic layer 14, the second magnetic layer 15, and the protective layer 16 was again carried out after substrate washing. Film production conditions and a lubricating layer 17 are the same as that of the medium of an example 1. The record reproducing characteristics in track-recording-density 400kFCI are collectively shown with the value of the coercive force measured towards intersecting perpendicularly with the magnetic-head transit direction of the medium of an example 4, and it, and a coercive force remanence ratio in Table 2. The value shown in the parenthesis of Hc and S* here is a value measured towards intersecting perpendicularly with the magnetic-head transit direction. The static magnetism property as the case (example 3) where the AlMg alloy substrate with NiP plating with which the magnetic anisotropy is given in the magnetic-head transit direction, and texture processing was performed is used with the same medium of an example 4 was acquired. Although record reproducing characteristics fell by 0.6dB by Slf/N compared with the medium of the example 2 of the same lamination except texture processing, the output resolution improved 1.1 point. When the medium of an example 4 was built into the magnetic storage of an example 1 and the conditions of 15nm of head flying heights, track-recording-density 425kFCI, and track density 25kTPI estimated record reproducing characteristics, in the 10 to 50 degrees C temperature requirement, the record reproducing-characteristics specification with a surface recording density of 10 gigabits [per 1 square inch] was fulfilled enough. And the number of bit errors after 50,000 head seeking trials from inner circumference to a periphery is 10 bits/page or less, and has attained 300,000 hours with Mean Time Between Failure.

[0018]

[Effect of the Invention] The magnetic storage which was excellent in dependability with a low error rate with high recording density is realizable with this invention.

[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the lamination of the magnetic-recording medium of one example of this invention.
[Drawing 2] Drawing showing the lamination of the magnetic-recording medium of the example of 1 comparison of this invention.
[Drawing 3] Drawing showing the X diffraction pattern of the magnetic-recording medium of an example 1 and the example 1 of a comparison.
[Drawing 4] The mimetic diagram and its A-A' drawing of longitudinal section of the magnetic storage which is one example of this invention.
[Drawing 5] The solid mimetic diagram showing the cross-section structure of the magnetic head in the magnetic storage of this invention.
[Drawing 6] The mimetic diagram of the longitudinal-section structure of the magnetic-reluctance sensor section of the magnetic head in the magnetic storage of this invention.
[Drawing 7] Drawing showing the lamination of the magnetic-recording medium of one example of this invention.
[Drawing 8] Drawing showing the lamination of the magnetic-recording medium of the example of 1 comparison of this invention.
[Drawing 9] Drawing showing the X diffraction pattern of the magnetic-recording medium of an example 2 and the example 3 of a comparison.
[Drawing 10] Drawing showing the lamination of the magnetic-recording medium of the example of 1 comparison of this invention.
[Description of Notations]
11 [... The first magnetic layer,] ... A substrate, 12 ... A seed layer, 13 ... A substrate layer, 14 15 [... Magnetic layer,] ... The second magnetic layer, 16 ... A protective layer, 17 ... A lubricating layer, 21 41 ... A magnetic-recording medium, 42 ... A magnetic-recording medium mechanical component, 43 ... Magnetic head, 44 ... A magnetic-head mechanical component, 45 ... A record regeneration system, 51 ... Record magnetic pole, 52 ... A magnetic-shielding [a magnetic pole-cum-] layer, 53 ... A coil, 54 ... Magneto-resistive effect component, 55 ... A conductor layer, 56 ... A magnetic-shielding layer, 57 ... Slider base, 61 ... The signal detection field of a magnetometric sensor, 62 ... A gap layer, 63 ... Buffer layer, 64 [... An antiferromagnetism alloy layer, 68 / ... The taper section, 69 / ... A permanent magnet layer, 70 / ... An electrode, 71 / ... An interlayer, 72 / ... Magnetic layer,] ... The first magnetic layer, 65 ... An interlayer, 66 ... The second magnetic layer, 67

[Translation done.]

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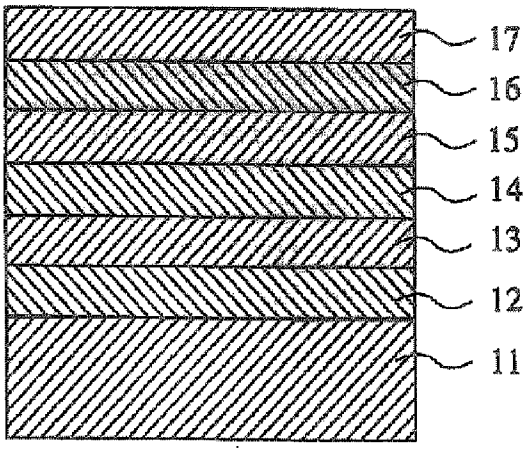
(71)出願人　000005108
株式会社日立製作所
東京都千代田区神田駿河台四丁目６番地
(72)発明者　棚橋　究
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72)発明者　神蔵　哲也
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(74)代理人　100075096
弁理士　作田　康夫

最終頁に続く

(54)【発明の名称】　磁気記録媒体および磁気記憶装置

(57)【要約】　（修正有）
【課題】　１平方インチあたり１０ギガビット以上の記録密度でエラーレートの低い、信頼性に優れた磁気記憶装置を提供する。
【解決手段】基板上にシード層および該シード層上に形成された下地層を介して形成された磁性層を有する磁気記録媒体において、前記磁気記録媒体のシード層をＮｉとＴａとＺｒを含む非晶質合金または微結晶合金とし、かつ、前記下地層をＣｒを主成分としＴｉを含む合金とし、かつ、前記磁性層を前記下地層と接する第一磁性層と該第一磁性層上に形成された第二磁性層で構成し、かつ、前記第一磁性層を実質的に六方最密（ＨＣＰ）構造のＣｏ－Ｃｒ－Ｐｔ合金とし、かつ、前記第二磁性層を実質的に六方最密（ＨＣＰ）構造のＣｏ－Ｃｒ－Ｐｔ－Ｂ合金とする。

図1



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【特許請求の範囲】

【請求項１】基板上に、ＮｉとＴａとＺｒとを含む非晶質合金または微結晶合金を有するシード層と、Ｃｒを主成分とする下地層と、磁性層とが順次形成された磁気記録媒体。

【請求項２】基板上に、ＮｉとＴａとＺｒとを含む非晶質合金または微結晶合金を有するシード層と、Ｃｒを主成分とし実質的に体心立方構造の結晶粒で構成されかつ前記結晶粒の（００１）面が基板と平行である下地層と、実質的に六方最密構造を有しＣｏ合金を主成分とする磁性層とが順次積層されたことを特徴とする磁気記録媒体。

【請求項３】前記下地層と前記磁性層との間に、ＣｒとＭｏとを含む合金を有する中間層を設けたことを特徴とする請求項１または請求項２に記載の磁気記録媒体。

【請求項４】基板上に、ＮｉとＴａとＺｒとを含む非晶質合金または微結晶合金を有するシード層と、ＣｒとＴｉとを含み実質的に体心立方構造の結晶粒で構成されかつ前記結晶粒の（００１）面が基板と平行である下地層と、ＣｏとＣｒとＰｔとを含む実質的に六方最密構造の第一磁性層と、ＣｏとＣｒとＰｔとＴａまたはＢを含む実質的に六方最密構造の第二磁性層とが順次積層された磁気記録媒体。

【請求項５】基板上に、ＮｉとＴａとＺｒとを含む非晶質合金または微結晶合金を有するシード層と、ＣｒとＴｉとを含み実質的に体心立方構造の結晶粒で構成されかつ前記結晶粒の（００１）面が基板と平行である下地層と、ＣｒとＭｏとを含む中間層と、ＣｏとＣｒとＰｔとＴａまたはＢを含む実質的に六方最密構造の磁性層とが順次積層された磁気記録媒体。

【請求項６】前記ＮｉとＴａとＺｒとを含むシード層は、Ｔａ濃度が３０ａｔ％以上６０ａｔ％以下であり、かつ、Ｚｒ濃度が５ａｔ％以上、２０ａｔ％以下であることを特徴とする請求項１から５に記載の磁気記憶媒体。

【請求項７】基板上に、ＮｉとＴａとＺｒとを含む非晶質合金または微結晶合金を有するシード層と、Ｃｒを主成分とし実質的に体心立方構造の結晶粒で構成されかつ前記結晶粒の（００１）面が基板と平行である下地層と、実質的に六方最密構造を有するＣｏ合金を主成分とする磁性層とが順次積層された磁気記録媒体と、該磁気記録媒体を回転駆動する駆動部と、記録部と磁気抵抗効果型磁気ヘッドで構成される再生部とを有する磁気ヘッドと、前記磁気ヘッドを前記磁気記録媒体に対して相対運動させる手段とを有することを特徴とする磁気記憶装置。

【請求項８】前記下地層と前記磁性層との間に、ＣｒとＭｏとを含む合金を有する中間層を設けたことを特徴とする請求項７記載の磁気記憶装置。

【請求項９】前記シード層は、Ｔａ濃度が３０ａｔ％以

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上６０ａｔ％以下であり、かつ、Ｚｒ濃度が５ａｔ％以上、２０ａｔ％以下であることを特徴とする請求項７または請求項８に記載の磁気記憶装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は磁気記憶装置および磁気記録媒体に係り、特に１平方インチあたり１０ギガビット以上の面記録密度を有する磁気記憶装置と、これを実現するための磁気記録媒体に関する。

【０００２】

【従来の技術】近年、コンピュータの扱う情報量は増加の一途をたどっており、外部記憶装置である磁気ディスク装置には、ますますの大容量化、高速転送化が求められている。現在のところ最高１平方インチあたり４ギガビッドクラスの記録密度を持つ磁気ディスク装置が製品化されるに到っている。こうした高密度磁気ディスク装置の磁気ヘッドには、記録部と再生部を分離し、記録部には電磁誘導型磁気ヘッドを、再生部には磁気抵抗効果型ヘッドを用いた複合型ヘッドが採用されている。磁気抵抗効果型ヘッドは、媒体の信号のみならずノイズに対しても感度が高いため、磁気記録媒体には従来以上の低ノイズ化が求められている。面内記録方式における媒体ノイズは、主に記録ビット間の磁化遷移領域における磁化の乱れに起因しており、この領域を狭くすることが媒体ノイズの低減につながる。これには、磁性粒子を微細化し、かつ、粒子間の相互作用を弱め、磁化反転サイズを小さくすることが有効である。磁性粒子の微細化は、磁性層と下地層間のエピタキシャル関係を利用し、下地粒子を微細化することで実現できる。また、粒子間の相互作用は、非磁性のＣｒを粒界に偏析させることで弱めることができ、このＣｒの偏析を促進するために、高Ｃｒ濃度のＣｏＣｒＰｔ合金、Ｔａ添加したＣｏＣｒＰｔＴａ合金、およびＢを添加したＣｏＣｒＰｔＢ合金等が検討されている。

【０００３】

【発明が解決しようとする課題】年々増加する線記録密度に対応するため、磁気記録媒体の保磁力（Ｈｃ）を高くする必要がある。高Ｃｒ濃度のＣｏＣｒＰｔ合金で、高いＨｃを得るにはＰｔ濃度を高める必要があるが、Ｐｔ濃度を高めると急激に重ね書き特性が低下する傾向がある。一方、Ｔａ添加したＣｏＣｒＰｔＴａ合金は、Ｃｒ濃度をそれ程高くしなくてもＣｒの粒界偏析が起こり、磁性粒子の磁気的孤立度が高いため、比較的低いＰｔ濃度で高いＨｃが得られる。しかし、ＣｏＣｒＰｔＴａ合金を用いた場合でも、媒体ノイズを更に低減するためにはＣｒ濃度を高める必要があり、また、より微細な粒径で高Ｈｃを確保するためにはＰｔ濃度を高める必要がある。ところが、ＣｏＣｒＰｔＴａ合金でＣｒ濃度とＰｔ濃度が高い組成では、下地層と磁性層のエピタキシャル成長が難しく、その結果、十分な磁気特性および記

録再生特性が得られない問題が生じる。また、こうした問題はＰｔ濃度を高めたＣｏＣｒＰｔＢ合金磁性層を用いた場合でも見られる。　本発明は、上記の課題を解決するためになされたものである。より具体的には、１平方インチあたり１０ギガビット以上の記録密度で高いＳ／Ｎを有し、かつ、信頼性に優れた磁気記憶装置を提供することを目的とする。

【０００４】

【課題を解決するための手段】本発明では、基板上に、シード層と、該シード層上に形成された単数または複数の下地層と、該下地層上に形成された単数または複数の磁性層とを有する磁気記録媒体と、これを記録方向に駆動する駆動部と、記録用の電磁誘導型磁気ヘッドと再生用の磁気抵抗効果型磁気ヘッドを組み合わせた録再分離型磁気ヘッドと、前記磁気ヘッドを前記磁気記録媒体に対して相対運動させる手段と、前記磁気ヘッドの信号入力と該磁気ヘッドからの出力信号再生を行うための記録再生信号処理手段を有する磁気記憶装置において、前記磁気記録媒体のシード層をＮｉとＴａとＺｒを含む非晶質合金または微結晶合金とし、かつ、前記単数または複数の下地層をＣｒを主成分としＴｉを含む合金とし、かつ、前記単数または複数の磁性層を前記下地層と接する第一磁性層と該第一磁性層上に形成された第二磁性層で構成し、かつ、前記第一磁性層を実質的にＨＣＰ構造のＣｏ－Ｃｒ－Ｐｔ合金とし、かつ、前記第二磁性層を実質的にＨＣＰ構造のＣｏ－Ｃｒ－Ｐｔ－Ｂ合金もしくはＣｏ－Ｃｒ－Ｐｔ－Ｔａ合金とすることで、上記の目的を達成する。前記磁気記録媒体の下地層は、実質的にＨＣＰ構造のＣｏ合金を用いた磁性層のＣ軸を膜面内に配向させ、かつ、粒子を微細化させる役割を持つ。高Ｐｔ濃度のＣｏＣｒＰｔ合金を磁性層に用いる場合は、一般的に用いられるＣｒ下地層では格子整合性に問題が生じるため、特開昭６２－２５７６１７号に開示されているように、実質的にＢＣＣ構造のＣｒ－Ｔｉ合金を用いることが有効である。ＣｒＴｉ合金は、Ｃｒにくらべ格子間隔が広いため、高Ｐｔ濃度のＣｏＣｒＰｔ合金と格子整合性がよく、また、粒径を微細にすることができる。

【０００５】しかしながら、Ｔｉ濃度を高くするに従い、下地層として望ましい結晶配向である（００１）配向が弱くなる問題がある。本発明者らは、基板と下地層の間に形成するシード層として種々の材料を検討したところ、ＮｉＴａＺｒ合金をシード層として用いた場合、ＣｒＴｉ合金下地層の（００１）配向が強くなり、かつ、下地粒径を小さくできることを見い出した。ＮｉＴａＺｒ合金はＸ線回折では明瞭な回折ピークがみられず、また、電子線回折でも明瞭な回折スポットおよび回折リングがみられないことから、非晶質もしくは微結晶になっていると考えられる。ＮｉＴａＺｒ合金の組成としては、Ｔａ濃度を３０ａｔ％以上、６０ａｔ％以下、Ｚｒ濃度を５ａｔ％以上、２０ａｔ％以下とするのが望ましい。Ｔａ濃度を前記範囲外にすると製膜条件によりＮｉＴａＺｒ合金の結晶化が起こる場合があり、ＣｒＴｉ合金下地層の（００１）配向性が劣化するため好ましくない。また、Ｚｒ濃度を５ａｔ％より少なくすると、ＣｒＴｉ合金下地層は強く（００１）配向するものの下地粒径が肥大化し、２０ａｔ％より大きくすると（００１）配向が劣化するため好ましくない。前記磁気記録媒体の磁性層は、下地層と接する第一磁性層と該第一磁性層上に形成された第二磁性層で構成し、前記第一磁性層の材料としてＣｏＣｒＰｔ合金を用い、前記第二磁性層の材料としてＣｏＣｒＰｔＴａ合金もしくはＣｏＣｒＰｔＢ合金を用いることができる。特にＣｏＣｒＰｔＢ合金は粒径が小さな場合でも高いＨｃが得られる傾向があり、出力分解能を高める上で望ましい。また、前記第二磁性層として磁気異方性の高いＣｏＰｔ合金と酸化物（ＳｉＯ２、Al_2O_3等）からなる、いわゆるグラニュラ構造の磁性層を用いることもできる。磁性層をＣｏＣｒＰｔ合金の単層とすると、Ｐｔ濃度が高い組成では重ね書き特性が劣化する傾向があり好ましくない。また、磁性層と下地層の間に、ＣｒＭｏ合金からなる中間層を形成した場合は、磁性層としてＣｏＣｒＰｔＴａ合金もしくはＣｏＣｒＰｔＢ合金の単層を用いることができる。また、ＣｏＰｔ合金と酸化物からなるグラニュラ構造の磁性層を用いることも可能である。特にＣｏＣｒＰｔＢ合金の単層を用いると、微細な粒径と高いＨｃを同時に得られる傾向があり、低い媒体ノイズと高い出力分解能を実現することができ望ましい。ＣｒＴｉ合金下地層の上に直接ＣｏＣｒＰｔＴａ合金もしくはＣｏＣｒＰｔＢ合金磁性層を形成した場合、ＣｒおよびＰｔ濃度が高い組成領域ではエピタキシャル成長が困難となるが、ＣｒＭｏ合金中間層は用いることでＣｏＣｒＰｔＴａ合金もしくはＣｏＣｒＰｔＢ合金磁性層のＣ軸を膜面内に配向させることができる。ＣｒＭｏ合金は全率固溶型の合金であるため、Ｃｒに比べ原子半径の大きなＭｏの濃度を調整することによりＣｏＣｒＰｔＴａ合金もしくはＣｏＣｒＰｔＢ合金磁性層との格子整合性を高めることができる。また、ＣｒＭｏ合金中間層の粒径は膜厚とともに増加する傾向があるため、膜厚が薄い範囲で用いる必要がある。ＣｒＭｏ合金中間層の膜厚は、良好な結晶配向性を保ち、かつ、粒径の肥大化を抑える点から３ｎｍ以上、１０ｎｍ以下とするのが望ましい。基板としては表面平滑性に優れたものを使用する必要があり、具体的にはＮｉＰが表面に形成されたＡｌ－Ｍｇ基板、ガラス基板、SiO_2基板、ＳｉＣ基板、カーボン基板等を用いることができる。Ａｌ－Ｍｇ基板は通常表面にテクスチャリング加工を施されており、基板周方向に磁気異方性が付与されているが、ガラス基板等の機械的なテクスチャリング加工が困難な基板の場合でも、シード層を形成後にＲａ＝１ｎｍ程度の軽いテクスチャリング加工を施すことで、基板周方向に磁気異方性を付与すること

ができる。　磁性層の保護層としては、カーボンを主成分とする厚さ３ｎｍ以上、１２ｎｍ以下の膜を形成し、更にパーフルオロアルキルポリエーテル等の潤滑層を１ｎｍ以上、１０ｎｍ以下の厚さで形成することにより、信頼性の高い磁気記録媒体が得られる。本発明の磁気記憶装置に用いる再生用磁気抵抗型磁気ヘッドの磁気抵抗センサ部は、互いに０．１２μｍ以上、０．１８μｍ以下の距離だけ隔てられた軟磁性体からなる２枚のシールド層の間に形成することが望ましい。シールド層の間隔が０．１８μｍよりも大きくなると分解能が低下するため好ましくなく、０．１２μｍより小さくなるとシールド層と磁気抵抗センサ部との絶縁性が損なわれる可能性があるため好ましくない。更に、前記磁気抵抗効果型ヘッドを、互いに磁化方向が外部磁界によって相対的に変化することによって大きな抵抗変化を生ずる複数の導電性磁性層と、該導電性磁性層の間に配置された導電性非磁性層を含む磁気抵抗センサによって構成することにより再生信号を高めることができ、１平方インチあたり１０ギガビット以上の記録密度で高い信頼性を有する磁気記憶装置を実現することができる。

【０００６】

【発明の実施の形態】実施例１：　図１に本実施例の磁気記録媒体の層構成を示す。基板１１にはアルカリ洗浄した２．５インチ型の化学強化されたソーダライムガラス*を、シード層１２には膜厚が５０ｎｍのＮｉ－３７．５ａｔ％Ｔａ－１０ａｔ％Ｚｒ合金層を、下地層１３には膜厚が３０ｎｍのＣｒ－２０ａｔ％Ｔｉ合金層を、第一磁性層１４には膜厚が１０ｎｍのＣｏ－２２ａｔ％Ｃｒ－１４ａｔ％Ｐｔ合金層を、第二磁性層１５には１０ｎｍのＣｏ－２１ａｔ％Ｃｒ－１２ａｔ％Ｐｔ－３ａｔ％Ｔａ合金層を、保護層１６には膜厚が６ｎｍのカーボン層を用い、ＤＣマグネトロンスパッタリング法により順次形成した。製膜条件は、アルゴンガス分圧は５ｍＴｏｒｒ、基板温度はシード層１２形成後、ランプヒーターにより２７０℃まで加熱した。潤滑層１７は、パーフルオロアルキルポリエーテル系の材料をフルオロカーボン材料で希釈し塗布した。また、比較例１として、シード層１２に膜厚が５０ｎｍのＮｉ－３７．５ａｔ％Ｔａ合金層を用いた媒体を、比較例２として、図２に示すように単層の磁性層２１に膜厚が１８ｎｍのＣｏ－２２ａｔ％Ｃｒ－１４ａｔ％Ｐｔ合金層を用いた媒体を作製した。

【０００７】表１に実施例１と比較例１、２の媒体の磁気ヘッド走行方向に測定した保磁力および保磁力角形比の値と、線記録密度４００ｋＦＣＩでの記録再生特性を示す。

【０００８】

【表１】

表1

	Hc [kOe]	S*	S/N [dB]	出力分解能 [%]	重ね書き特性 [dB]
実施例１	2.95	0.73	31.4	55.0	37.7
比較例１	3.25	0.76	27.6	54.7	36.1
比較例２	3.14	0.75	28.3	55.3	29.8
実施例２	2.92	0.72	32.5	54.8	37.9
比較例３	0.51	0.02	-	-	-

【０００９】記録再生特性は、シールド層間距離が０．１５μｍとしたスピンバルブ型の再生素子と、ギャップ長が０．２３μｍの電磁誘導型書き込み素子からなる磁気ヘッドを用いた。Ｓｌｆは孤立再生波の出力、Ｎは４００ｋＦＣＩの線記録密度での媒体ノイズであり、これらの比Ｓｌｆ／Ｎで媒体Ｓ／Ｎを評価した。出力分解能は２００ｋＦＣＩの再生出力を２５ｋＦＣＩの再生出力で割った値を百分率で表示した。また、重ね書き特性として、まず1f信号（４７．５ｋＦＣＩ）書き込み、2f信号（４００ｋＦＣＩ）を重ね書きした後の1f信号の消え残り強度を評価した。実施例１および比較例１、２の媒体の静磁気特性は、Ｈｃが約３ｋＯｅ、Ｓ*が約０．７５とほぼ同等の値が得られた。実施例１の媒体の記録再生特性は、比較例１の媒体に比べ出力分解能は同等であったが、Ｓｌｆ／Ｎが３．８ｄＢ高く、良好であった。比較例２の媒体は出力分解能が５５．３％と高い値が得られたものの、実施例１の媒体に比べＳｌｆ／Ｎが３．１ｄＢ低く、また、重ね書き特性が２９．８ｄＢと実用上必要とされる３６ｄＢを大きく下回った。実施例１と比較例１の媒体のＳｌｆ／Ｎの差の要因を明らかにするため、Ｘ線回折法により結晶配向性を調べた。

【００１０】Ｘ線回折は、ＣｕをターゲットとするＸ線回折装置（理学製ＲＩＮＴ）を使用して行った。線源としてはＫα線を用いた。測定条件はθ－２θ法を用い、印加電圧４０ｋＶ、印加電流１００ｍＡとした。

【００１１】媒体のＸ線回折パターンを図３に示す。両媒体とも、下地層の００２回折ピークと磁性層のＨＣＰ構造の１１．０回折ピークのみが見られ、シード層からの回折ピークは確認できない。シード層の膜厚が５０ｎｍと比較的厚いにもかかわらず回折ピークが見られないことから、Ｎｉ－３７．５ａｔ％Ｔａ－１０ａｔ％Ｚｒ合金およびＮｉ－３７．５ａｔ％Ｔａ合金は非晶質もしくは非常に微細な結晶になっていると考えられる。シード層上に形成された下地層は両媒体とも（００１）配向しているが、比較例１の媒体の００２回折ピーク強度は実施例１の媒体のそれに比べ３倍以上強い。原子間力顕微鏡により、両媒体の下地層の表面形態を観察したところ、実施例１の媒体は周期が１２ｎｍ程度の凹凸が見ら

れたのに対し、比較例１の媒体は周期が１６ｎｍ程度の凹凸が見られた。この凹凸はほぼ結晶粒の大きさに対応していると考えられることから、比較例１の媒体では下地層の粒径が肥大化していることがわかる。すなわち、シード層にＮｉＴａ合金を用いると下地層は強い（００１）配向が得られるが、下地粒径が肥大化し、磁性粒子の微細化が実現できない。それに対し、シード層にＺｒを添加したＮｉＴａＺｒ合金を用いることで、下地層の（００１）配向を保ったまま、下地粒径の肥大化を抑制でき、その結果、磁性粒子が微細化される。したがって、実施例１の媒体のＳｌｆ／Ｎが比較例１の媒体のそれに比べ３．８ｄＢ高いのは、磁性粒径の微細化が主因と考えられる。本実施例の磁気記憶装置の平面模式図および縦断面模式図を図４（ａ）および図４（Ｂ）に示す。この装置は、磁気記録媒体４１と、これを回転駆動する駆動部４２と、磁気ヘッド４３およびその駆動手段４４と、前記磁気ヘッドの記録再生信号処理手段４５を有してなる周知の構成を持つ磁気記憶装置である。この磁気記憶装置に用いた磁気ヘッドの構造の模式図を図５に示す。この磁気ヘッドは、磁気ヘッドスライダ基体５７の上に形成された記録用の電磁誘導型磁気ヘッドと再生用の磁気抵抗効果型ヘッドを組み合わせた録再分離型ヘッドである。記録用磁気ヘッドは、一対の記録磁極５１、５２とそれに鎖交するコイル５３からなる誘導型薄膜磁気ヘッドであり、記録磁極間のギャップ層厚は０．２３μｍとした。また、磁極５２はともに厚さ１μｍの磁気シールド層５６と対で、再生用の磁気ヘッドの磁気シールドも兼ねており、このシールド層間距離は０．１５μｍである。再生用磁気ヘッドは、磁気抵抗効果センサ５４と、電極となる導体層５５からなる磁気抵抗効果型ヘッドである。なお、図５では記録磁極間のギャップ層およびシールド層は省略してある。図６に磁気抵抗センサの縦断面構造を示す。磁気センサの信号検出領域６１は、酸化Ａｌのギャップ層６２上に５ｎｍのＴａバッファ層６３、７ｎｍの第一の磁性層６４、１．５ｎｍのＣｕ中間層６５、３ｎｍの第二の磁性層６６、１０ｎｍのＦｅ－２０ａｔ％Ｍｎ反強磁性合金層６７が順次形成された構造である。第一の磁性層６４にはＮｉ－２０ａｔ％Ｆｅ合金を用い、第二の磁性層６６にはＣｏを用いた。反強磁性合金６７からの交換磁界により、第二の磁性層６６の磁化は一方向に固定されている。これに対し、第二の磁性層６６と非磁性の中間層６５を介して接する第一の磁性層６４の磁化の方向は、磁気記録媒体からの漏洩磁界により変化する。このような二つの磁性層の磁化の相対的な方向の変化に伴い、三層の膜全体の抵抗に変化が生じる。この現象はスピンバルブ効果と呼ばれている。信号検出領域６１の両端にはテーパー形状に加工されたテーパー部６８がある。テーパー部６８は永久磁石層６９と、その上に形成された信号を取り出すための一対の電極７０から構成される。永久磁石６９は保磁力が高く、磁化方向が容易に変化しないことが重要であり、ＣｏＣｒ、ＣｏＣｒＰｔ合金等が用いられる。実施例１の媒体を上記磁気記憶装置に組み込んでヘッド浮上量１５ｎｍ、線記録密度４２５ｋＦＣＩ、トラック密度２５ｋＴＰＩの条件で記録再生特性を評価したところ、１０℃から５０℃の温度範囲において、１平方インチあたり１０ギガビットの面記録密度の記録再生特性仕様を十分満たした。しかも、内周から外周までのヘッドシーク試験５万回後のビットエラー数は１０ビット/面以下であり、平均故障間隔で３０万時間が達成できた。

【００１２】実施例２：　図７に本実施例で用いた磁気記録媒体の層構成を示す。中間層７１として５ｎｍのＣｒ－４０ａｔ％Ｍｏ合金を、磁性層７２として１８ｎｍのＣｏ－２１ａｔ％Ｃｒ－１３ａｔ％Ｐｔ－４ａｔ％Ｂ合金を用い、その他の層および製膜条件は実施例１の媒体と同様である。また、比較例３として、図８に示すように下地層１３の上に直接磁性層７２を形成した媒体を作製した。表１に実施例２と比較例３の媒体の磁気ヘッド走行方向に測定した保磁力および保磁力角形比の値と、線記録密度４００ｋＦＣＩでの記録再生特性を併せて示す。実施例２の媒体は、実施例１の媒体と同等な静磁気特性が得られ、また、記録再生特性はＳｌｆ／Ｎが３２．５ｄＢと高い値が得られた。一方、比較例３の媒体は、Ｈｃが０．５１ｋＯｅ、S^*が０．０２と記録再生特性を評価するのに十分な静磁気特性が得られなかった。実施例２と比較例３の媒体のＸ線回折パターンを図９に示す。Ｘ線回折の測定条件は、実施例１と同様である。

【００１３】実施例２の媒体では、中間層７１の回折ピークは膜厚が５ｎｍと薄いこともあり確認できないが、磁性層７２のＨＣＰ構造の１１．０回折ピークが見られることから、下地層１３と中間層７１が（００１）配向し、その上にエピタキシャル成長することで、磁性層が（１１．０）配向していることがわかる。一方、比較例３の媒体は、磁性層７２のＨＣＰ構造の００．２回折ピークが見られ、磁性層のＣ軸が基板に対して垂直に立ち上がった配向となる。このように、実施例２の媒体の中間層７１として用いたＣｒ－４０ａｔ％Ｍｏ合金は、磁性層７２のＣ軸を膜面内に配向させ、静磁気特性を向上させる役割を持つ。実施例２の媒体を実施例１の磁気記憶装置に組み込んでヘッド浮上量１５ｎｍ、線記録密度４２５ｋＦＣＩ、トラック密度２５ｋＴＰＩの条件で記録再生特性を評価したところ、１０℃から５０℃の温度範囲において、１平方インチあたり１０ギガビットの面記録密度の記録再生特性仕様を十分満たした。しかも、内周から外周までのヘッドシーク試験５万回後のビットエラー数は１０ビット/面以下であり、平均故障間隔で３０万時間が達成できた。

【００１４】実施例３：　実施例２の媒体と同様な層構成で、基板１１に２．５インチ型のＮｉＰメッキが施されたＡｌ－Ｍｇ合金基板を用いた媒体を作製した。なお、

基板１１にはＲａ＝３ｎｍのテクスチャリング加工を施した。製膜条件および潤滑層１７は実施例１の媒体と同様である。また、比較例４として、図１０に示すように基板１１の上に下地層１３を直接形成した媒体を作製した。　表２に実施例３と比較例４の媒体の磁気ヘッド走＊行方向およびそれと直交する方向で測定した保磁力および保磁力角形比の値と、線記録密度４００ｋＦＣＩでの記録再生特性を併せて示す。

【００１５】

【表２】

表2

	Hc [kOe]	S*	SNR [dB]	出力分解能 [%]	重ね書き特性 [dB]
実施例３	3.24 (2.85)	0.78 (0.60)	29.2	56.6	37.5
比較例４	3.01(2.90)	0.70 (0.66)	29.3	52.9	37.3
実施例４	3.12 (2.74)	0.76 (0.51)	31.9	55.9	37.2

＊括弧内に示す値は、磁気ヘッド走行方向と直交する方向で測定した値

【００１６】ここでＨｃとＳ*の括弧内に示す値は、磁気ヘッド走行方向と直交する方向で測定した値である。実施例３の媒体は、磁気ヘッド走行方向に磁気異方性が付与され、ＨｃおよびＳ*が比較例４の媒体に比べＨｃで０．２３ｋＯｅ、Ｓ*で０．０８高い値が得られた。これはシード層１２を形成することで、下地層１３の（００１）配向性および磁性層の（１１．０）配向が強くなり、テクスチャリング加工による磁気異方性付与の効果が高められたためと考えられる。これにより、出力分解能は比較例４の媒体に比べ３．７％高い値が得られた。実施例３の媒体を実施例１の磁気記憶装置に組み込んでヘッド浮上量１５ｎｍ、線記録密度４２５ｋＦＣＩ、トラック密度２５ｋＴＰＩの条件で記録再生特性を評価したところ、１０℃から５０℃の温度範囲において、１平方インチあたり１０ギガビットの面記録密度の記録再生特性仕様を十分満たした。しかも、内周から外周までのヘッドシーク試験５万回後のビットエラー数は１０ビット/面以下であり、平均故障間隔で３０万時間が達成できた。

【００１７】実施例４：　実施例２と同様な層構成で、シード層１２を形成後、製膜装置から取りだし、Ｒａ＝１ｎｍのテクスチャリング加工を施し、再度基板洗浄後、下地層１３、第一磁性層１４、第二磁性層１５および保護層１６を順次形成した。製膜条件および潤滑層１７は実施例１の媒体と同様である。表２に実施例４の媒体の磁気ヘッド走行方向およびそれと直交する方向で測定した保磁力および保磁力角形比の値と、線記録密度４００ｋＦＣＩでの記録再生特性を併せて示す。ここでＨｃとＳ*の括弧内に示す値は、磁気ヘッド走行方向と直交する方向で測定した値である。実施例４の媒体は、磁気ヘッド走行方向に磁気異方性が付与されており、テクスチャ加工が施されたＮｉＰメッキ付きＡｌＭｇ合金基板を用いた場合（実施例３）と同様な静磁気特性が得られた。記録再生特性は、テクスチャー加工以外は同様な層構成の実施例２の媒体と比べ、Ｓｌｆ／Ｎで０．６ｄＢ低下したものの出力分解能は１．１ポイント向上した。実施例４の媒体を実施例１の磁気記憶装置に組み込んでヘッド浮上量１５ｎｍ、線記録密度４２５ｋＦＣＩ、トラック密度２５ｋＴＰＩの条件で記録再生特性を評価したところ、１０℃から５０℃の温度範囲において、１平方インチあたり１０ギガビットの面記録密度の記録再生特性仕様を十分満たした。しかも、内周から外周までのヘッドシーク試験５万回後のビットエラー数は１０ビット/面以下であり、平均故障間隔で３０万時間が達成できた。

【００１８】

【発明の効果】本発明により、高記録密度でエラーレートの低い信頼性に優れた磁気記憶装置が実現できる。

【図面の簡単な説明】

【図１】本発明の一実施例の磁気記録媒体の層構成を示す図。

【図２】本発明の一比較例の磁気記録媒体の層構成を示す図。

【図３】実施例１および比較例１の磁気記録媒体のＸ線回折パターンを示す図。

【図４】本発明の一実施例である磁気記憶装置の平面模式図およびそのＡ－Ａ‘縦断面図。

【図５】本発明の磁気記憶装置における磁気ヘッドの断面構造を示す立体模式図。

【図６】本発明の磁気記憶装置における磁気ヘッドの磁気抵抗センサ部の縦断面構造の模式図。

【図７】本発明の一実施例の磁気記録媒体の層構成を示す図。

【図８】本発明の一比較例の磁気記録媒体の層構成を示す図。

【図９】実施例２および比較例３の磁気記録媒体のＸ線回折パターンを示す図。

【図１０】本発明の一比較例の磁気記録媒体の層構成を示す図。

【符号の説明】

１１・・・基板、１２・・・シード層、１３・・・下地層、１４・・・第一磁性層、１５・・・第二磁性層、１６・・・保護層、１７・・・潤滑層、２１・・・磁性層、４１・・・磁気記録媒体、４２・・・磁気記録媒体駆動部、４３・・・磁気ヘッド、４４・・・磁気ヘッド駆動部、４５・・・記録再生処理系、５１・・・記録磁極、５２・・・磁極兼磁気シールド層、５３・・・コイル、５４・・・磁気抵抗効果素子、５５・・・導体層、

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５６・・・磁気シールド層、５７・・・スライダ基体、６１・・・磁気センサの信号検出領域、６２・・・ギャップ層、６３・・・バッファ層、６４・・・第一の磁性層、６５・・・中間層、６６・・・第二の磁性層、６７＊

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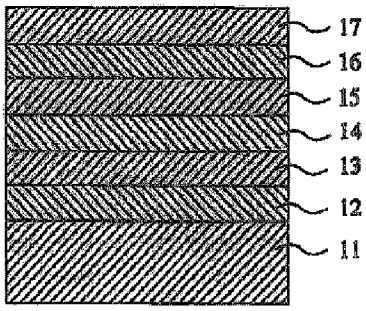
＊・・・反強磁性合金層、６８・・・テーパー部、６９・・・永久磁石層、７０・・・電極、７１・・・中間層、７２・・・磁性層。

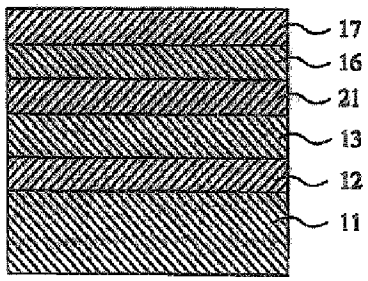
【図１】

図1



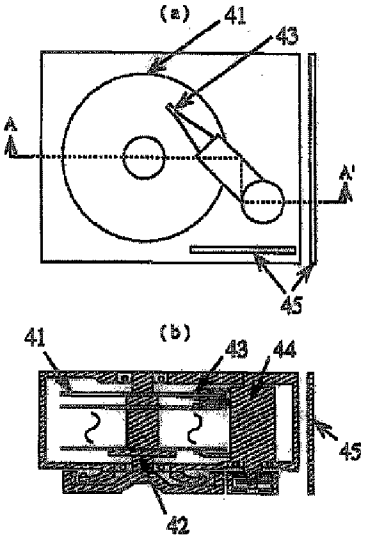
【図２】

図2



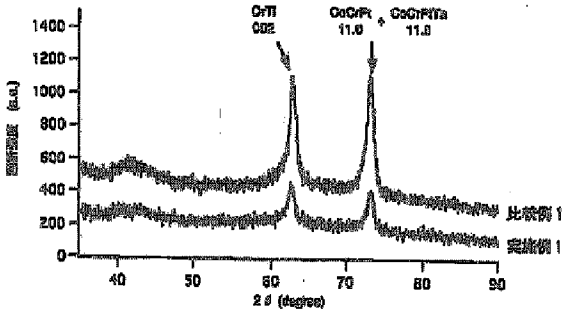
【図４】

図４



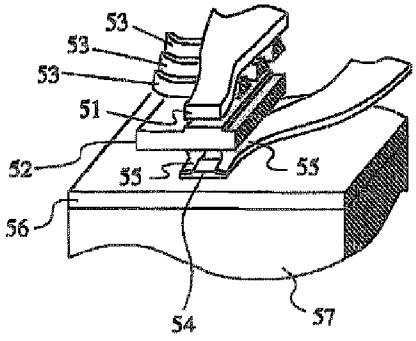
【図３】

図3



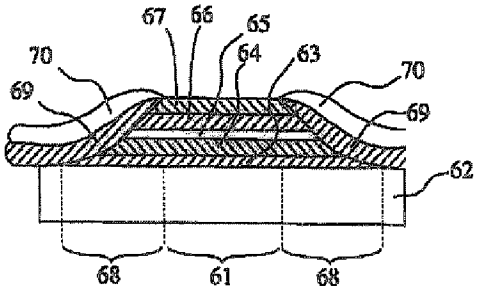
【図５】

図5



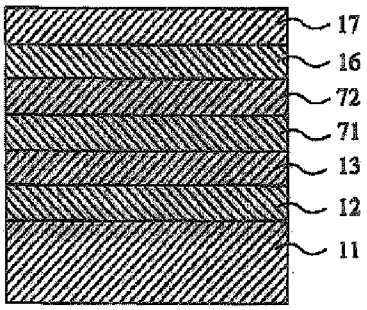
【図６】

図6



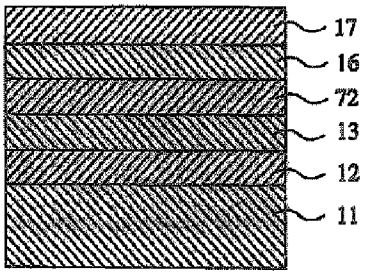
【図７】

図7



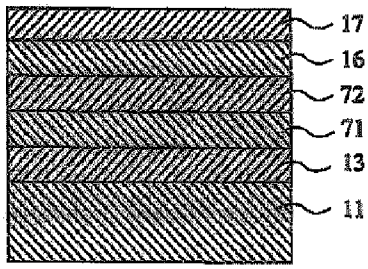
【図８】

図8



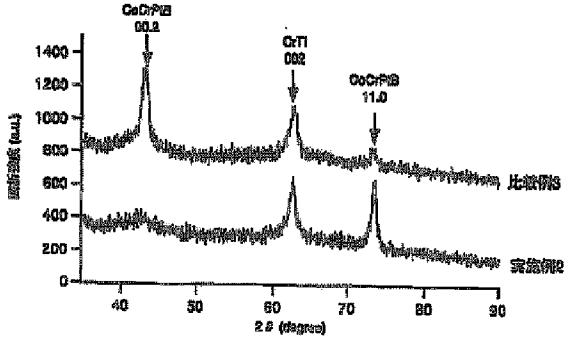
【図１０】

図10



【図９】

図9



フロントページの続き

(72)発明者　松沼　悟
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内

(72)発明者　石川　晃
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内

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